Current Status of $\pi^+\pi^0\gamma$ analysis

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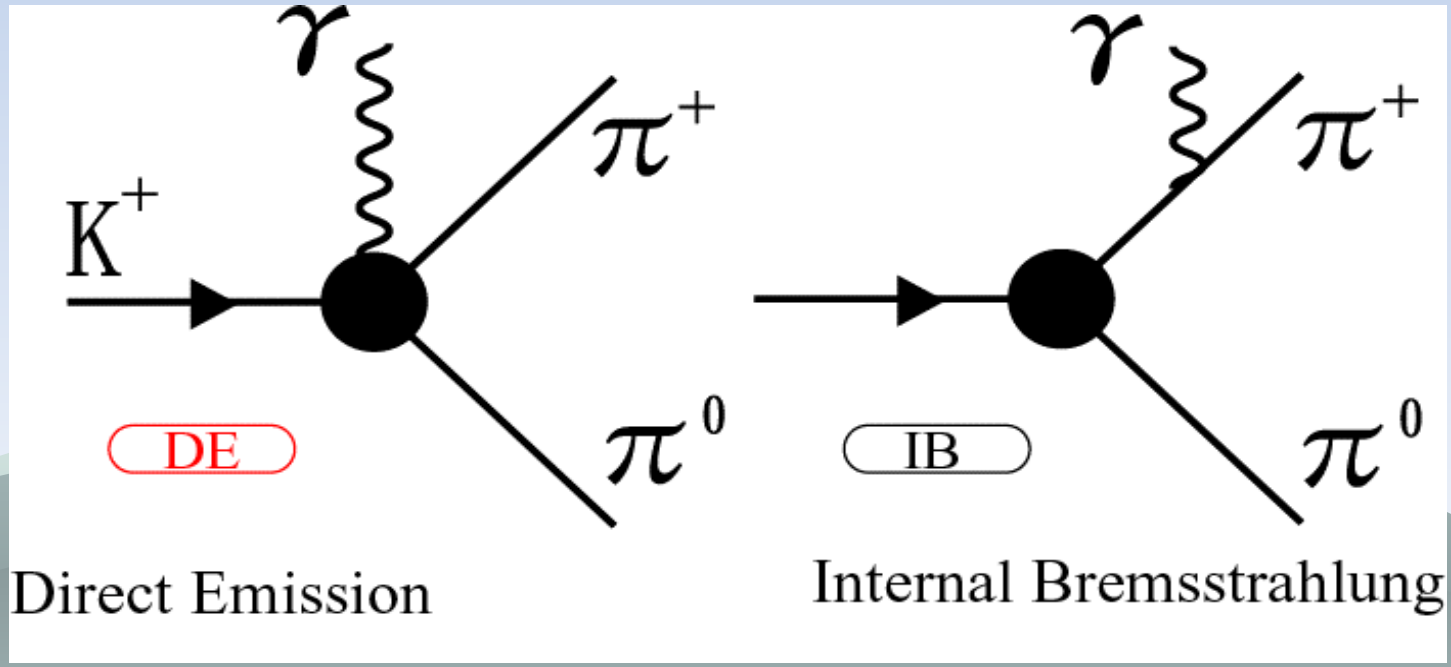
Outline

1. Theory
2. Kinetic region in this analysis
3. correction on target
4. consistency between real data and UMC
5. summary

IB and DE component



About 2%

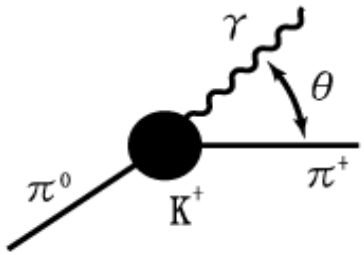
About 98%

Spectrum for IB and DE separation

IB INT DE

$$\frac{\partial^2\Gamma}{\partial T_+ \partial W} = \frac{\partial^2\Gamma_{IB}}{\partial T_+ \partial W}\left(1 + 2\frac{m_{\pi^+}^2}{m_K} Re\left(\frac{E}{\epsilon A}\right)W^2 + \frac{m_{\pi^+}^2}{m_K^2}\left(\left|\frac{E}{\epsilon A}\right|^2 + \left|\frac{M}{\epsilon A}\right|^2\right)W^4\right)$$

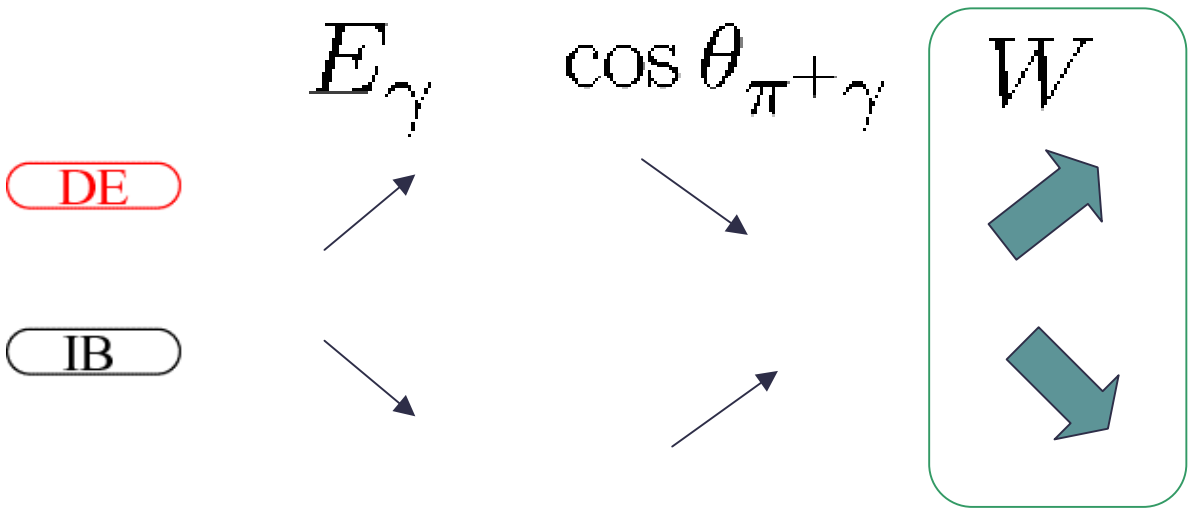
$$W^2 = \frac{E_\gamma^2 \times (E_{\pi^+} - P_{\pi^+} \times \cos\theta_{\pi^+\gamma})}{m_{K^+} \times m_{\pi^+}^2}$$



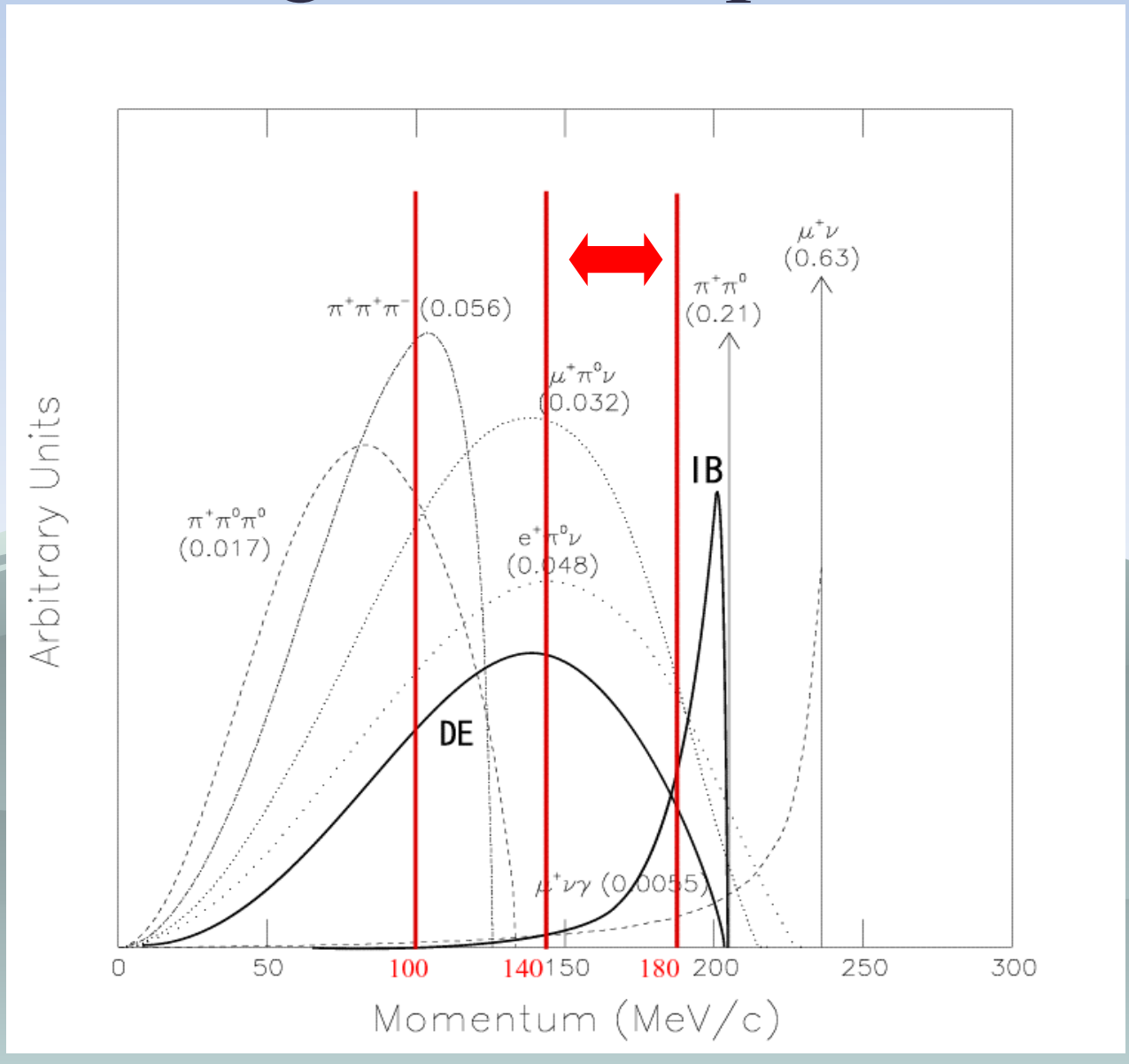
E_γ	radiated gamma energy	$\cos\theta_{\pi^+\gamma}$	opening angle between pion and gamma
E_{π^+}	pion energy	m_{K^+}	kaon mass
P_{π^+}	pion momentum	m_{π^+}	pion mass

W spectrum

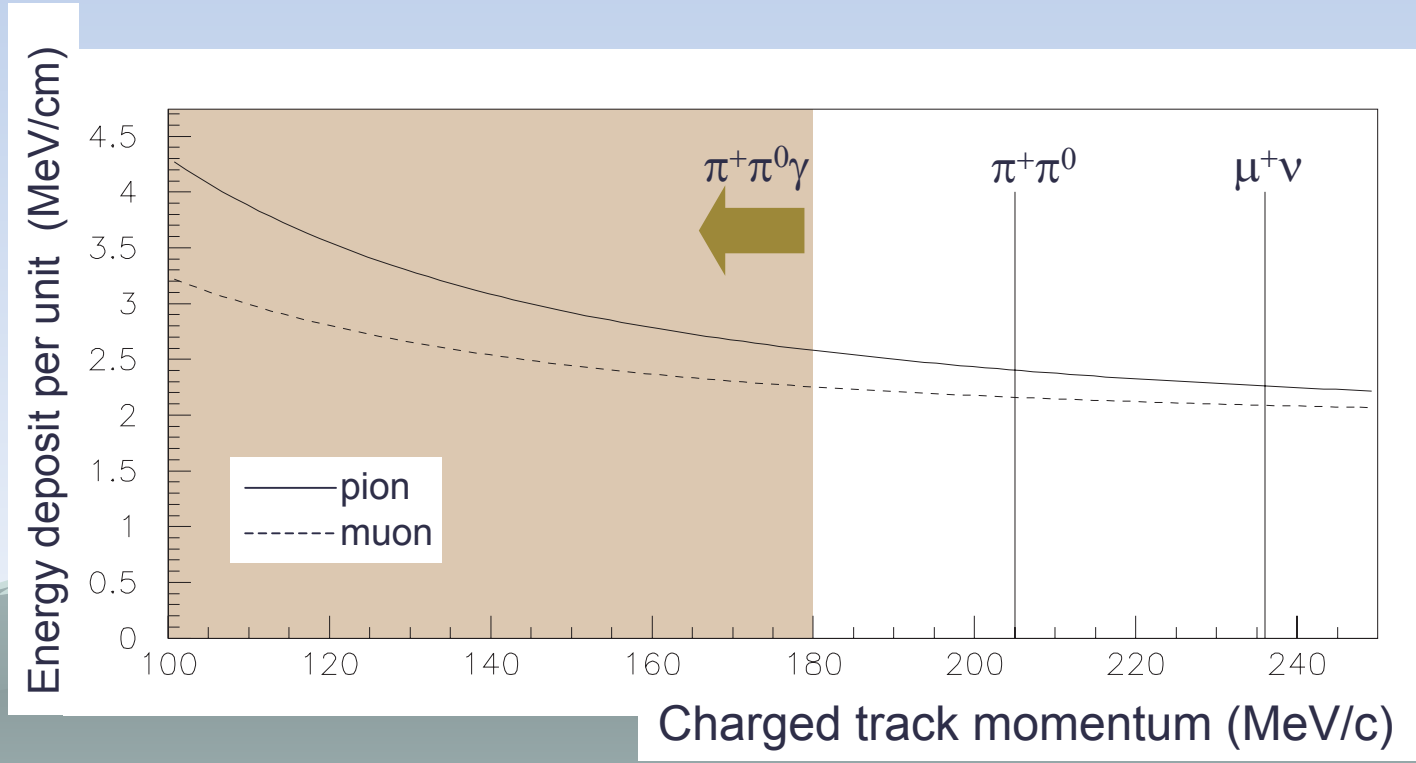
$$W^2 = \frac{E_\gamma^2 \times (E_{\pi+} - P_{\pi+} \times \cos\theta_{\pi+\gamma})}{m_{K^+} \times m_{\pi+}^2}$$



Charged track spectrum



dE/dx in scintilator



dE/dX is large

TARGET plays more important role

Correction on target

- Azimuthal angle of charged track
- Range in target
- Energy deposit in target

Study with UMC was performed

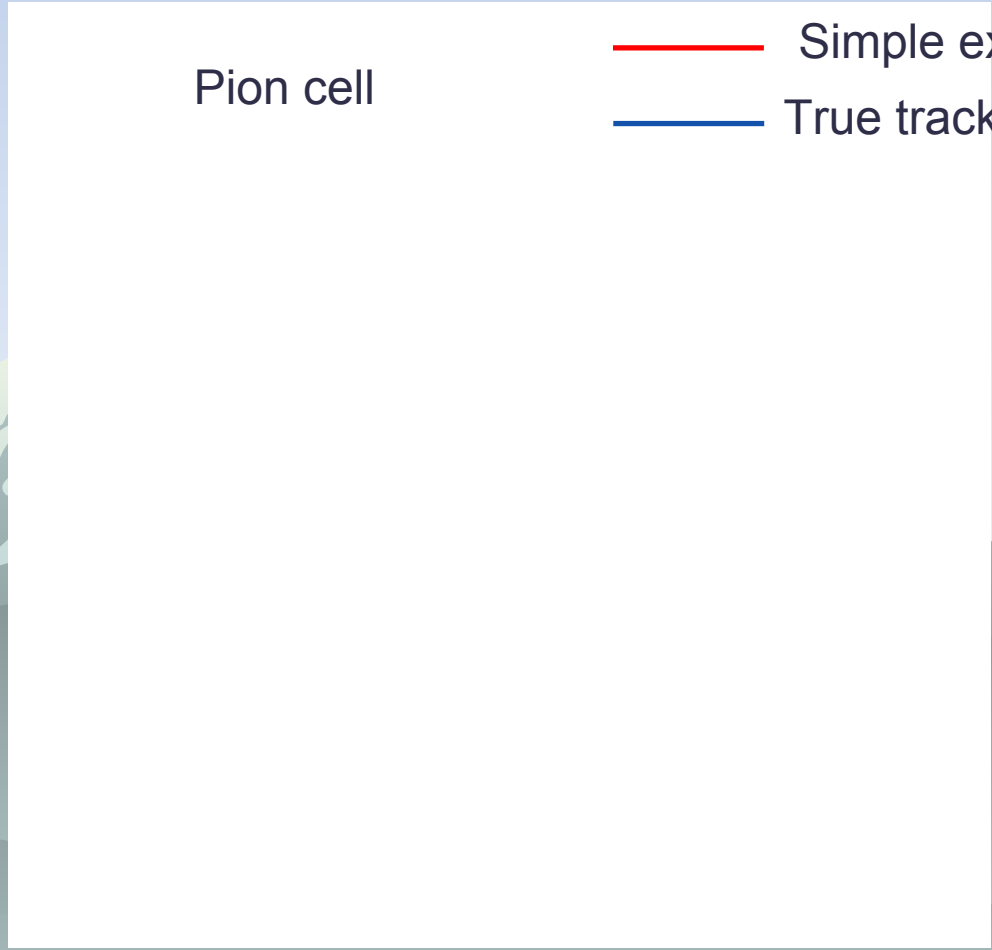
UMC provides us true value of the measured variables.

Azimuthal angle

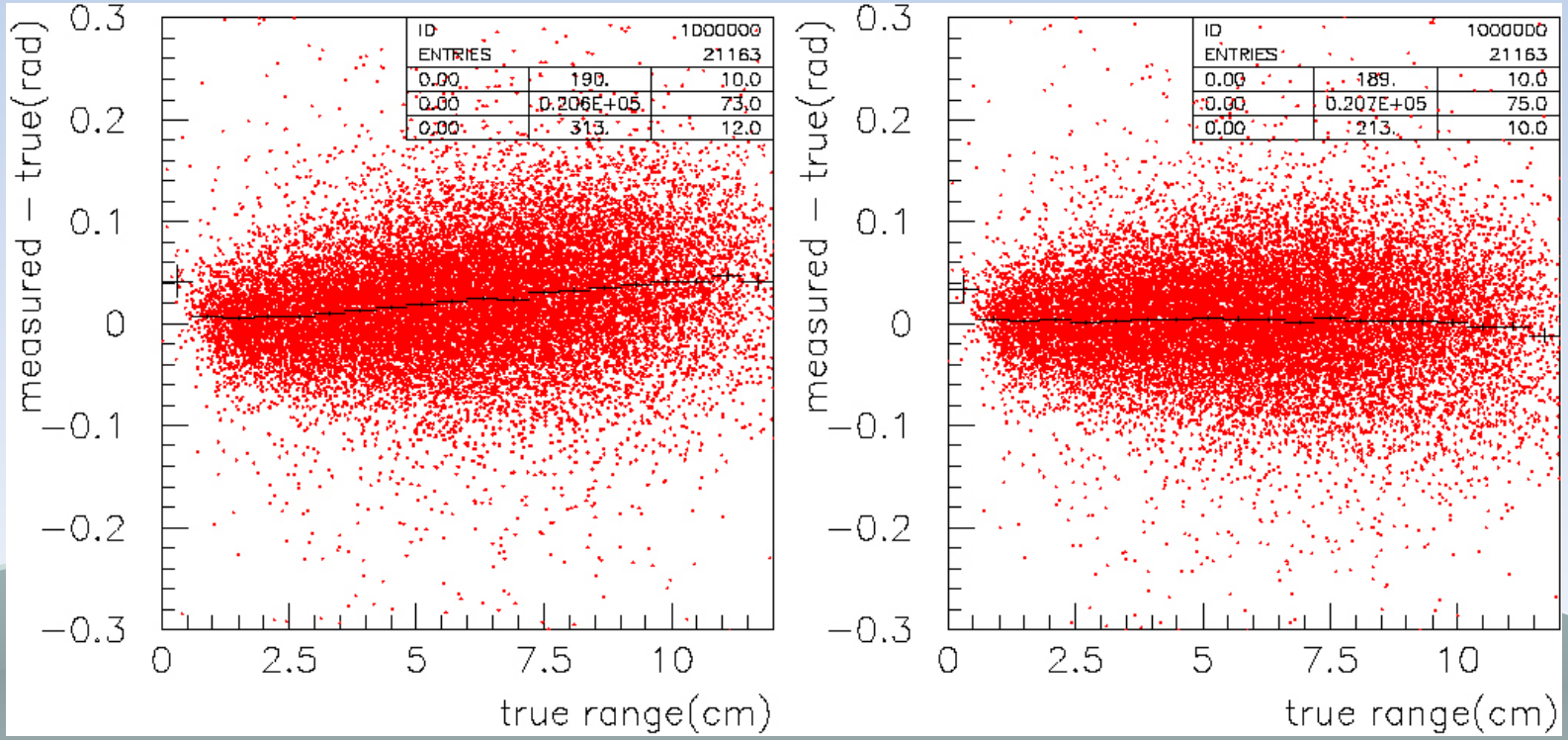
E787 standard extrapolate the UTC track, assuming that the track in target is a part of circle. This means energy deposit in target is neglected.

New method

Step by step extrapolation. Energy deposit is calculated, being based on Bethe-bloch formula.



Azimuthal angle



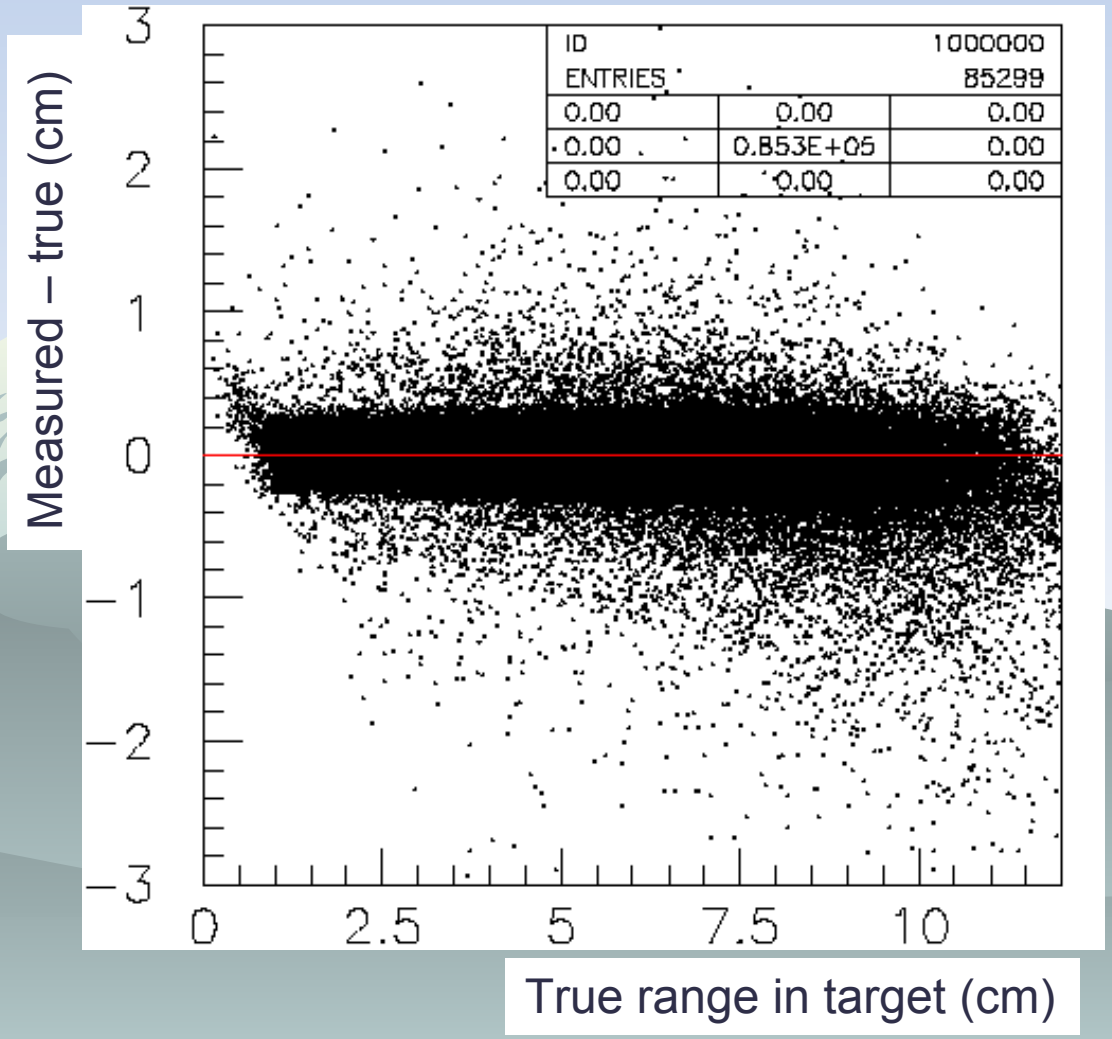
E787 standard
Energy deposit in target is neglected.

New method.
Energy deposit is calculated, being based on Bethe-Bloch formula.

Resolution of azimuthal angle for kinetic fitting is estimated well

Range in target

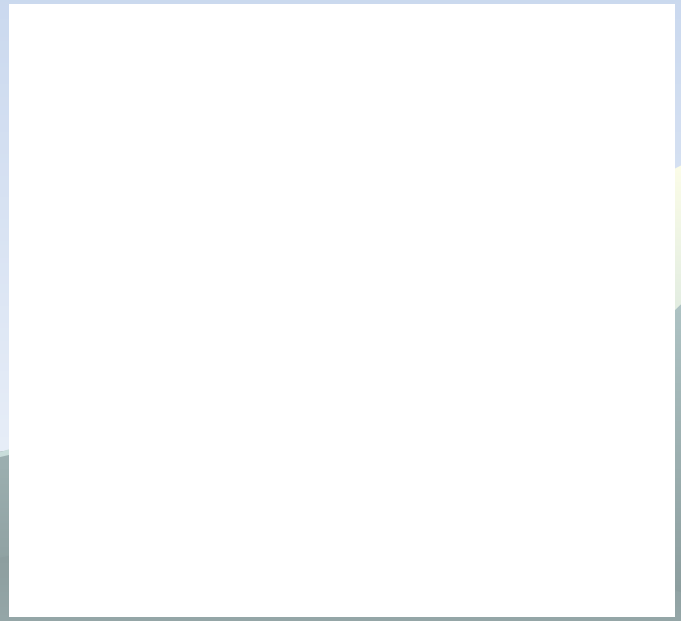
B4-SWATH mode in target reconstruction did not work. It is fixed.



range in target

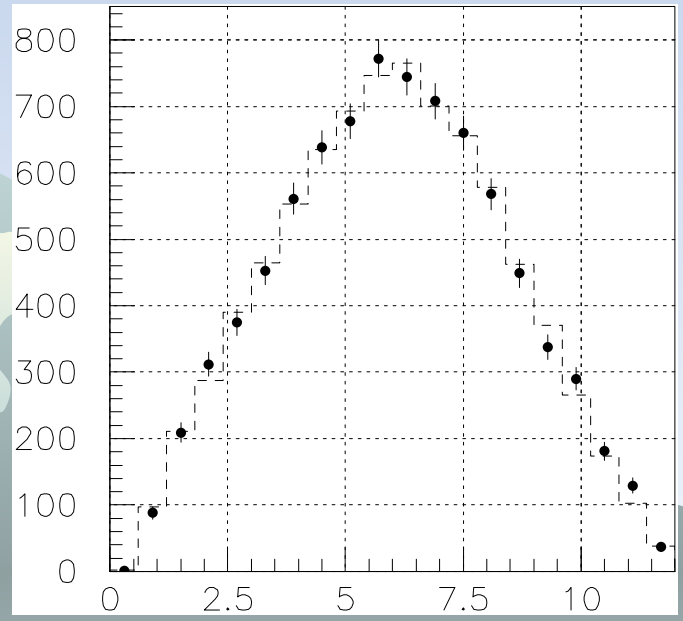
- Real
------- UMC

previous



Range in target (cm)

new

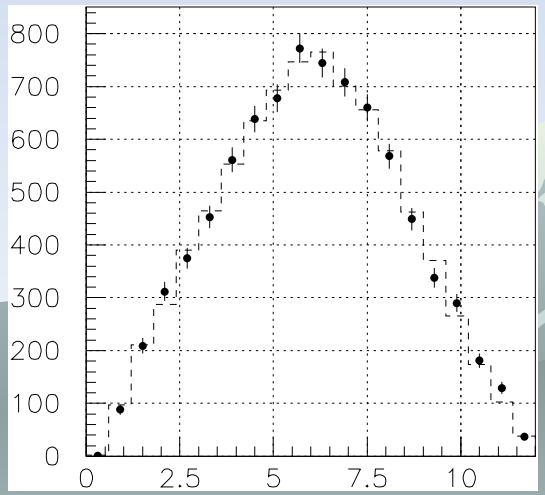


Range in target (cm)

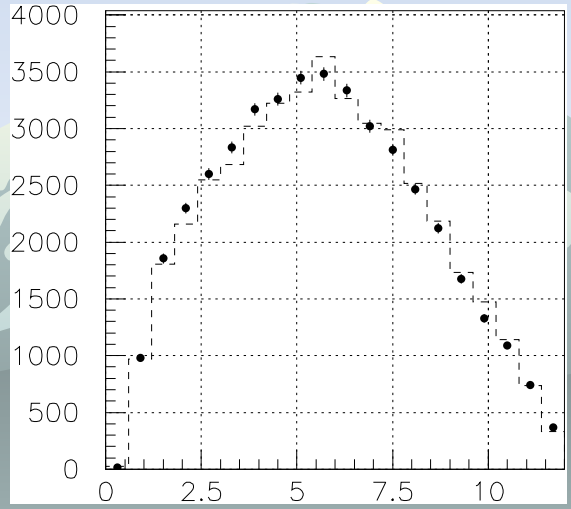
(normalized by number of events)

Range in target (cm)

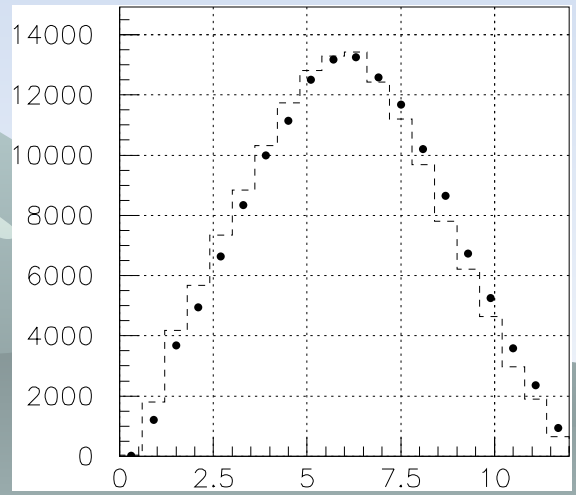
- Real
------- UMC



$\pi^+\pi^0\gamma$



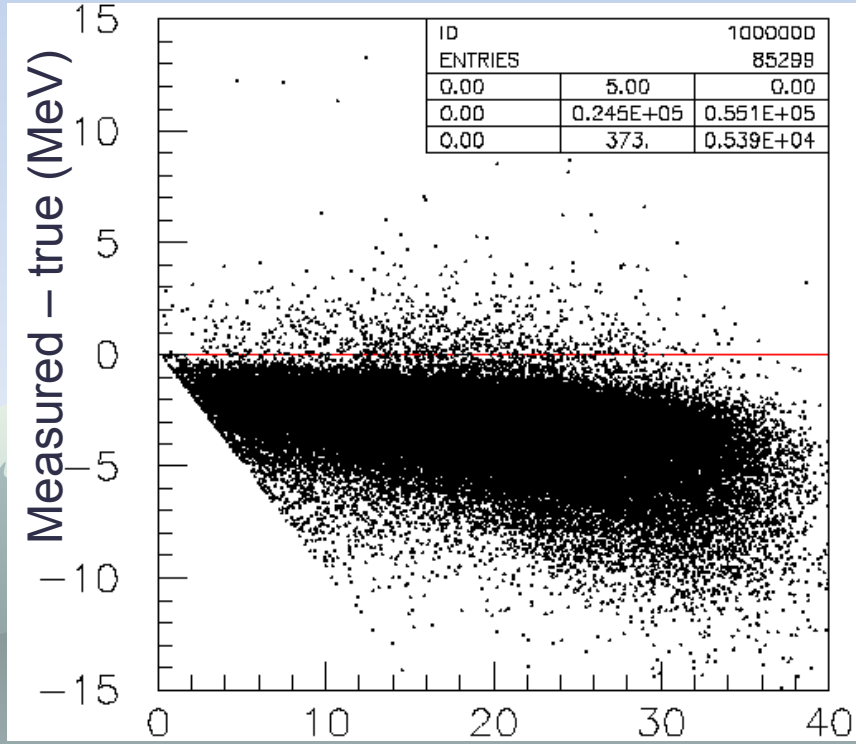
$\pi^+\pi^0$



$\mu^+\nu$

Consistency between real and UMC is retained

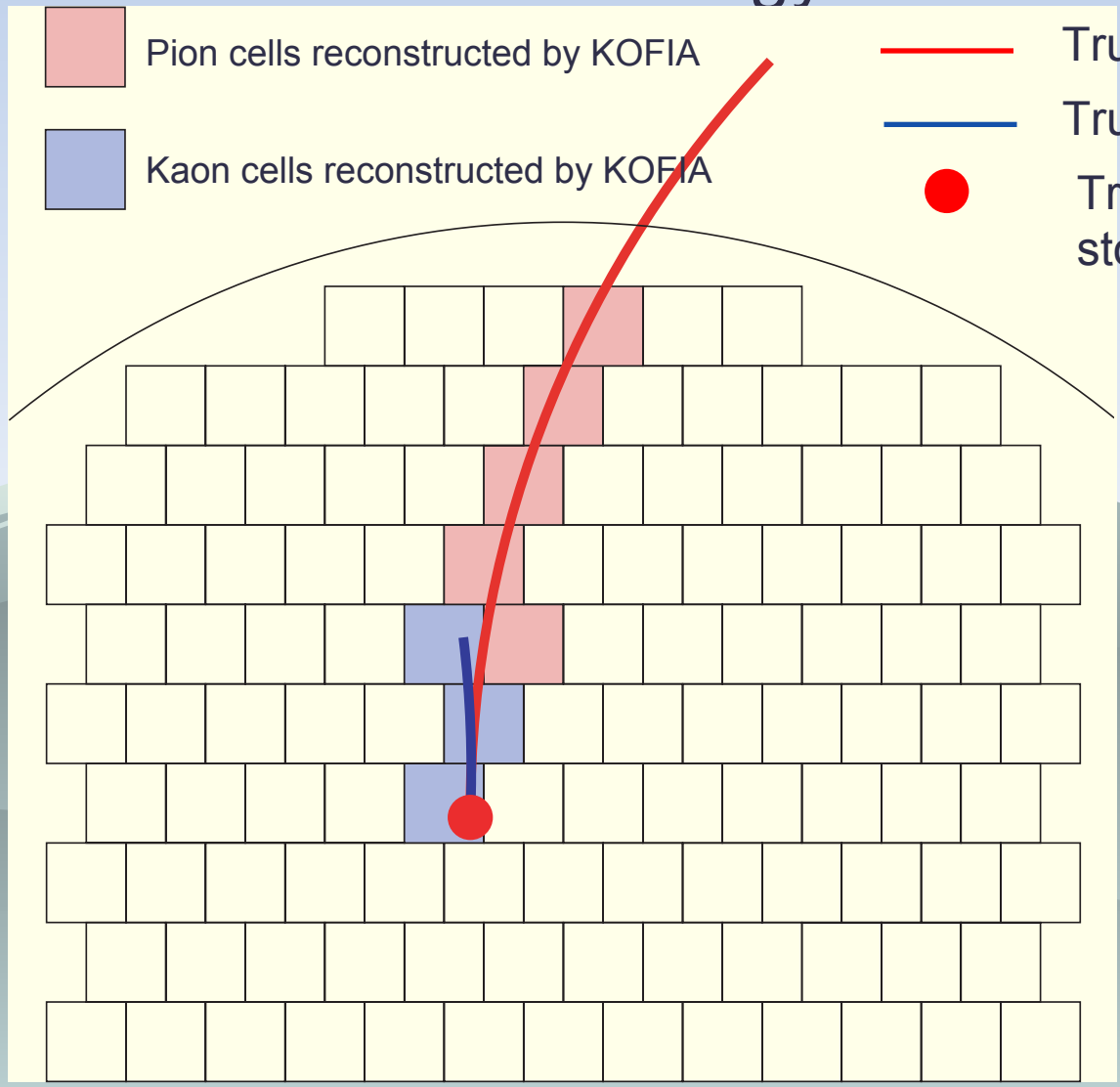
Energy deposit in target



- Hidden energy
- Energy deposit in edge fiber
- Saturation effect

Energy deposit in target

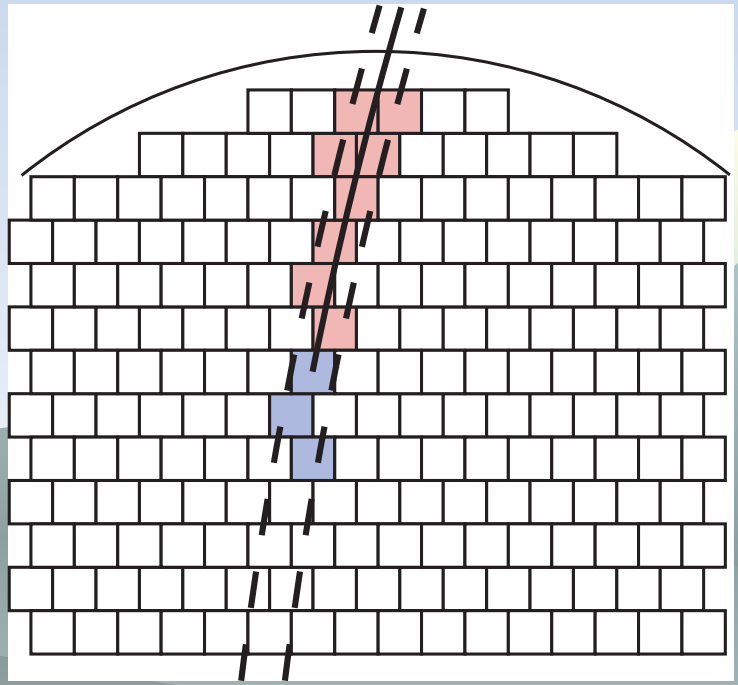
Hidden Energy



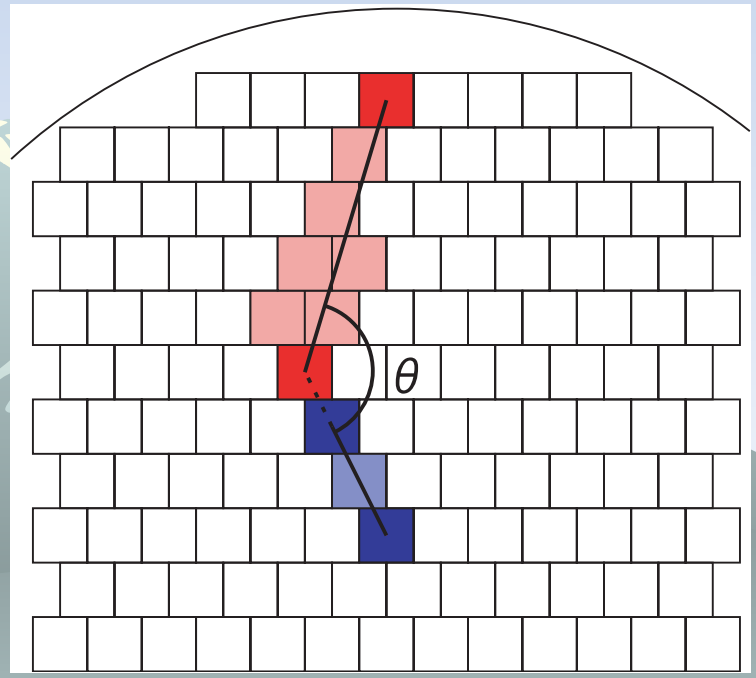
Energy deposit in target

Hidden energy

Two measurable variables are used for correction



Number of kaon cells in swath



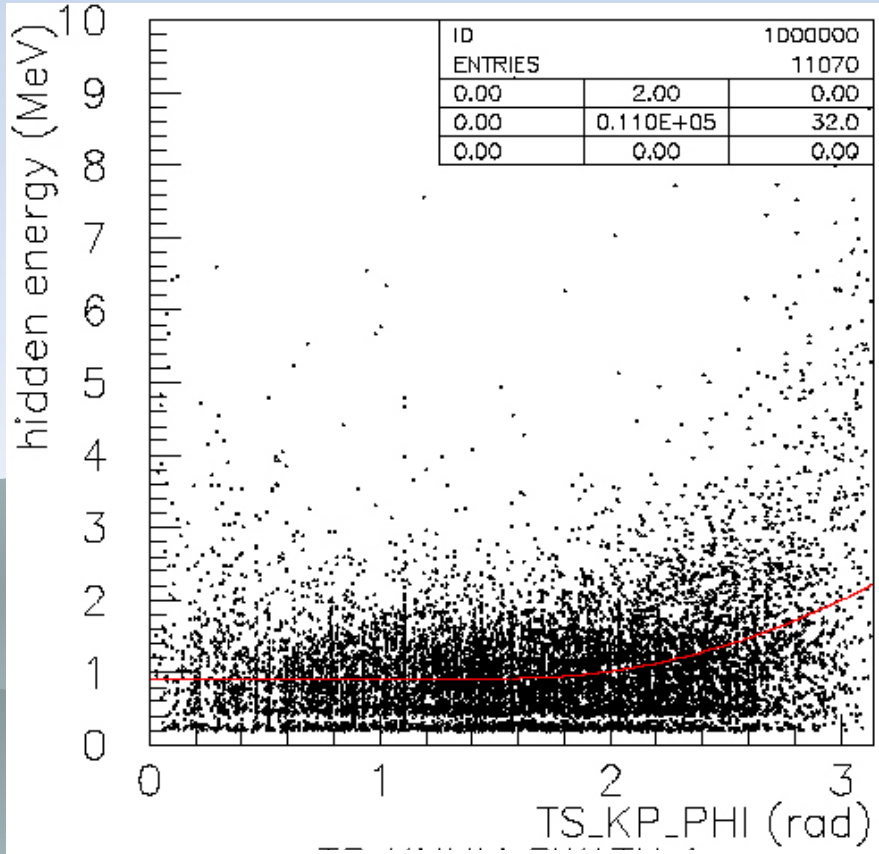
Angle between kaon and pion

Hidden energy depends on two variables

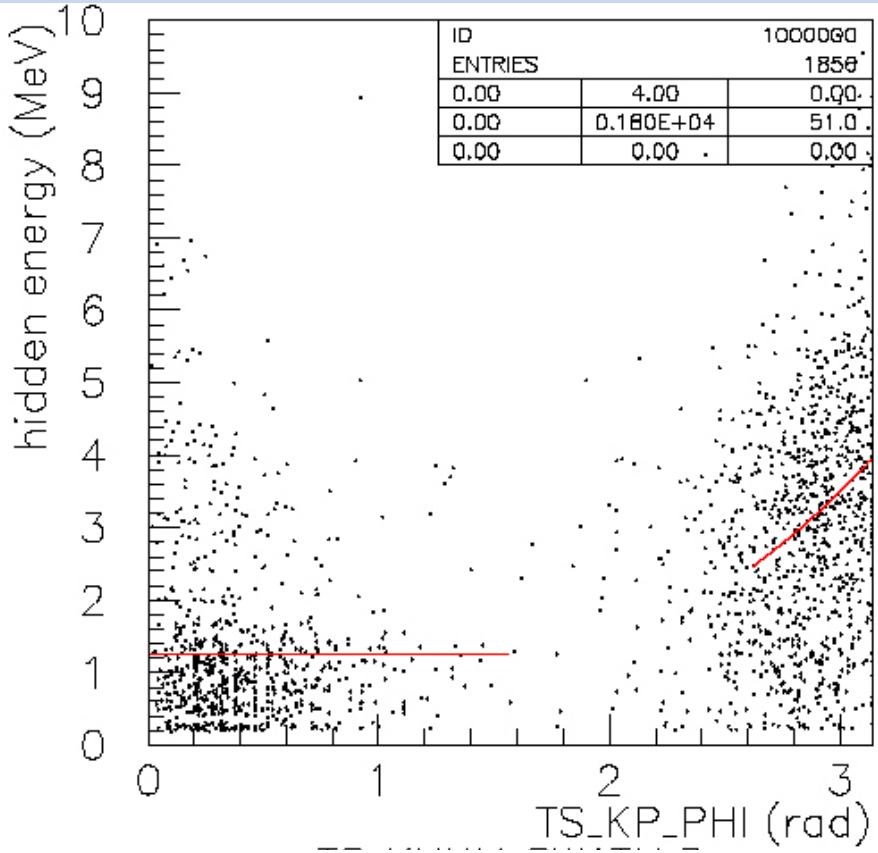
Energy deposit in target

Hidden energy

Angle between kaon and pion vs. hidden energy



Number of kaon cells in swath= 1

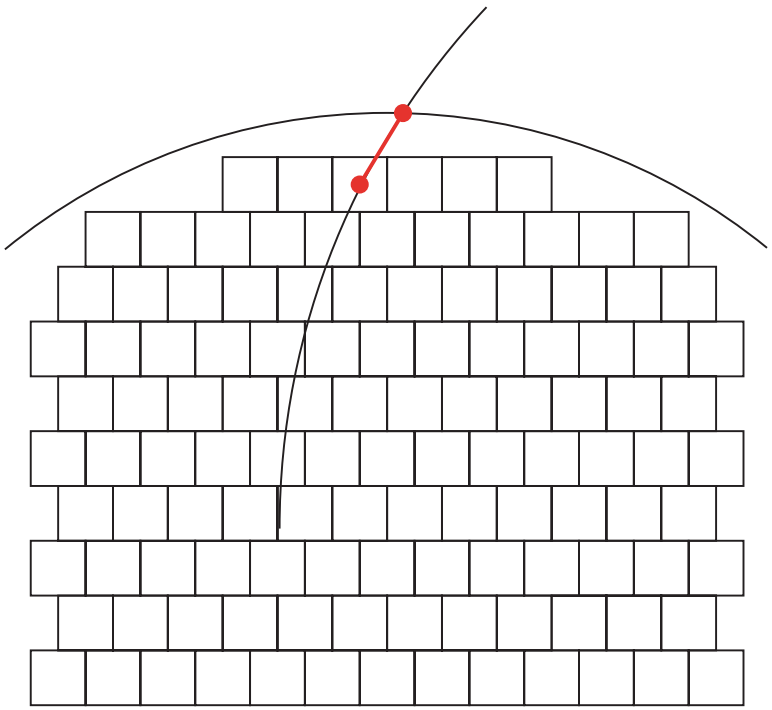


Number of kaon cells in swath= 3

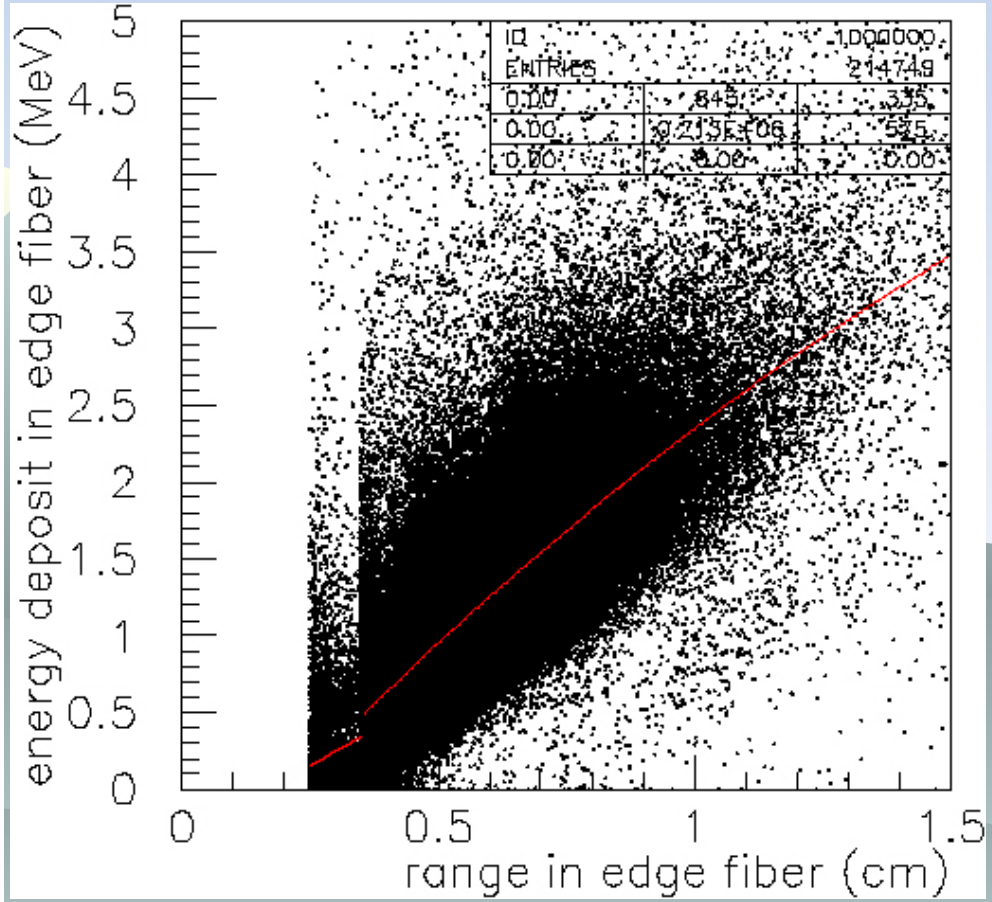
Events whose number of kaon cells in swath is from 1 to 5 are corrected.
Here are examples. If the number is larger than 5, correction isn't made.

Energy deposit in target

energy deposit in edge fiber



TS_D_EDGE is length of red line after correction of dip angle



TS_D_EDGE

Energy deposit in target

Saturation effect

Saturation effect :

Unsaturated energy – saturated energy

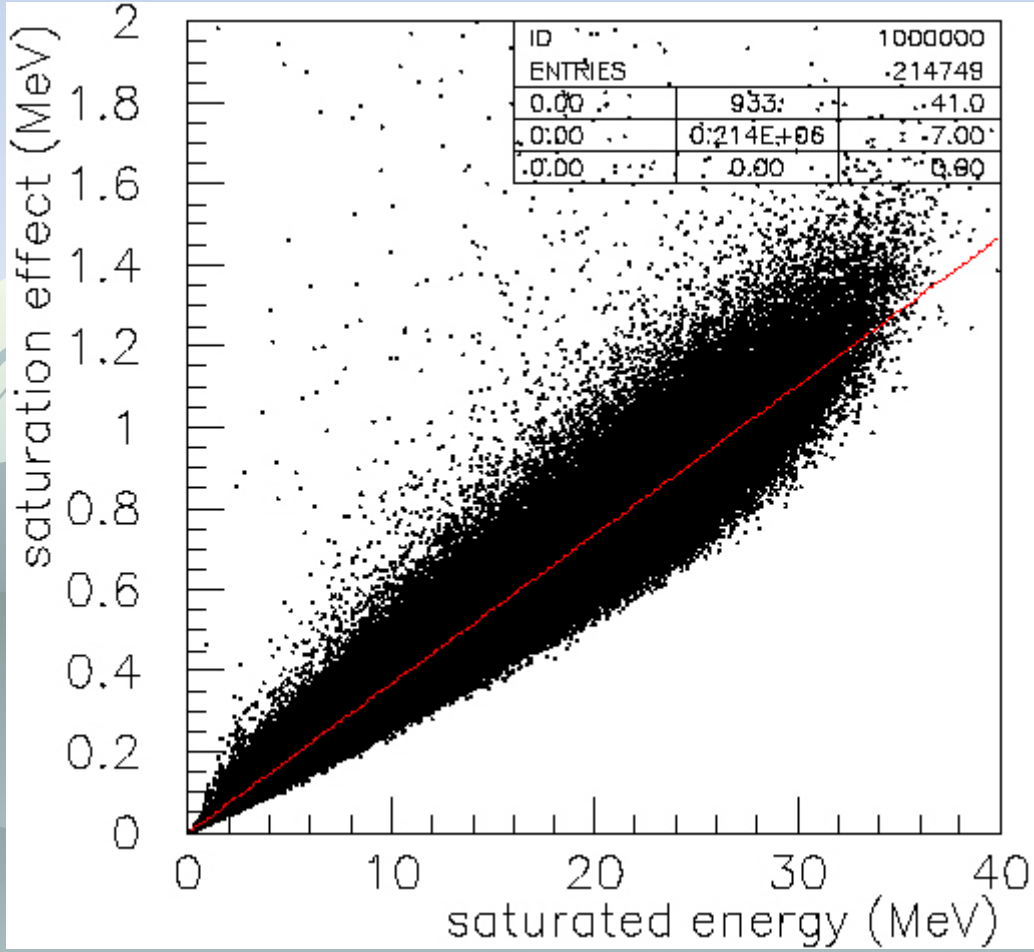
Saturation is based on birk's formula

REAL data

Calibration on target includes saturation effect. This effect is already considered.

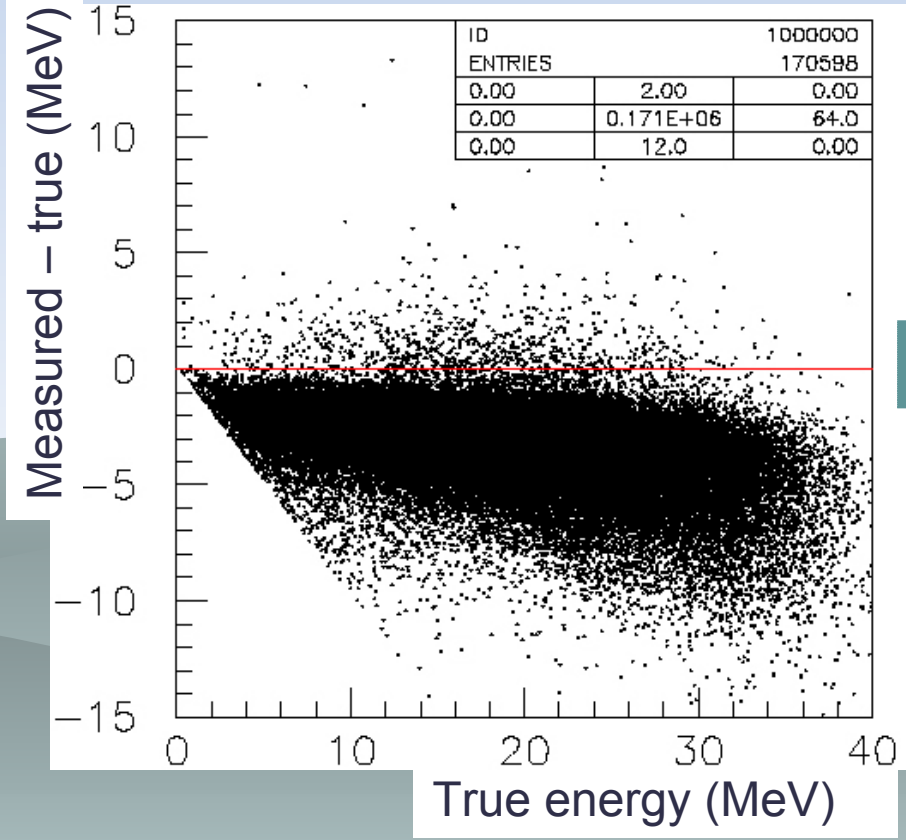
UMC data

Saturation effect should be considered.

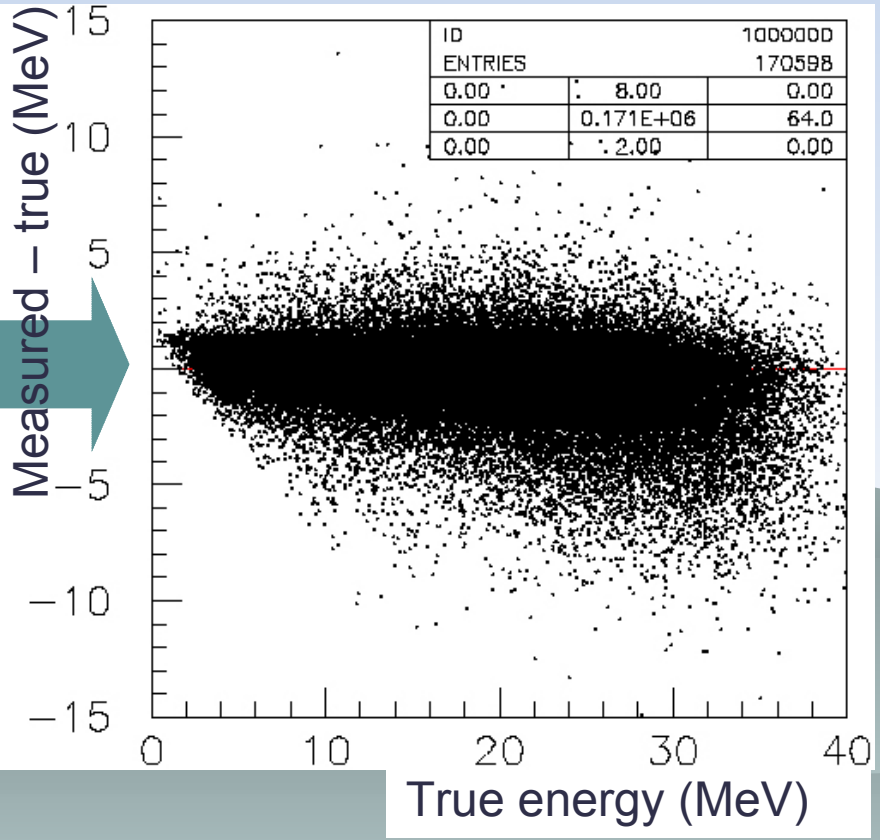


before and after energy calibration in target

before



after



Energy deposit in target (ETG)

Trigger 3gamma
Pion assumption

Trigger kp21
Pion assumption

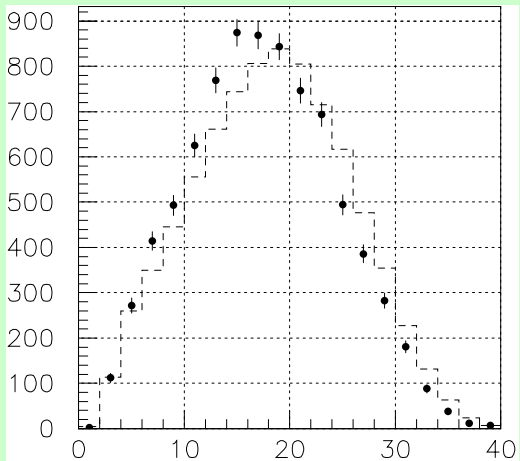
Trigger km21
Muon assumption

OLD

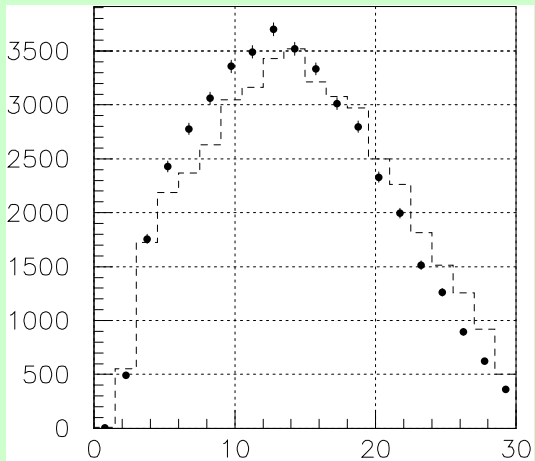
E787 standard

NEW

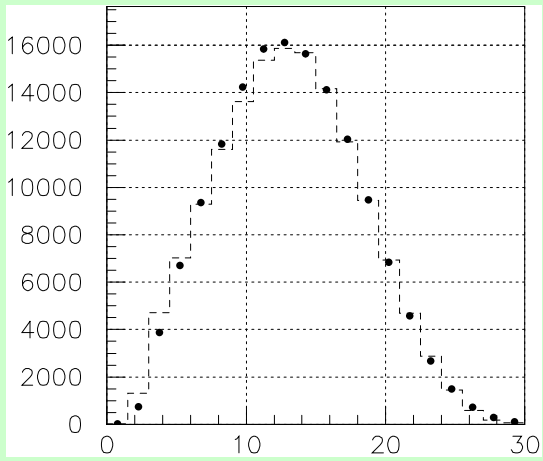
After correction



$\pi^+\pi^0\gamma$ MeV



$\pi^+\pi^0$ MeV



$\mu^+\nu$ MeV

Summary of target correction

1) **Azimuthal angle**

New method is employed. Dependence on range is removed.

2) **Range in target**

A bug is fixed. Consistency of range in target is improved.

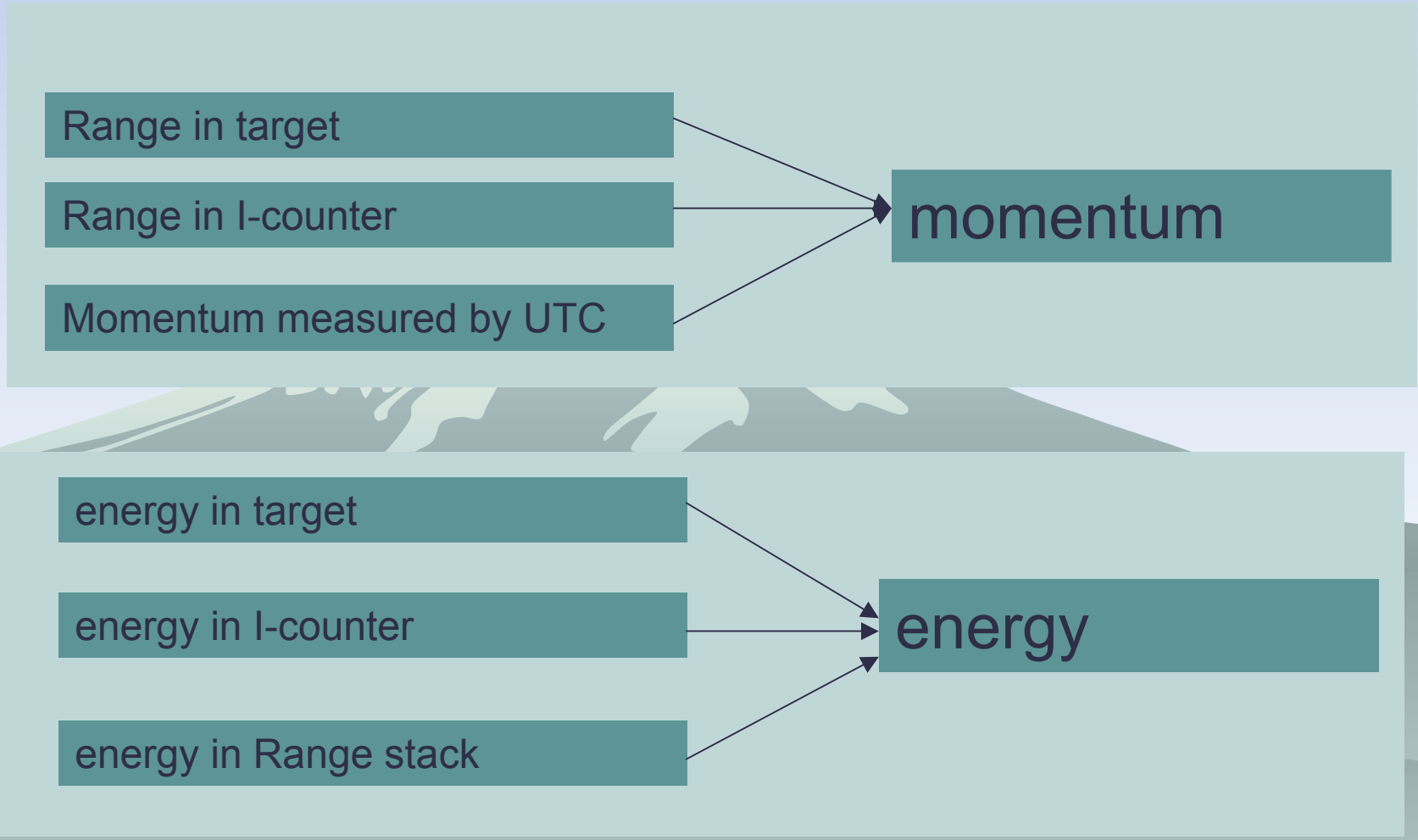
3) **Energy deposit in target**

(1) hidden energy

(2) energy deposit in edge fiber

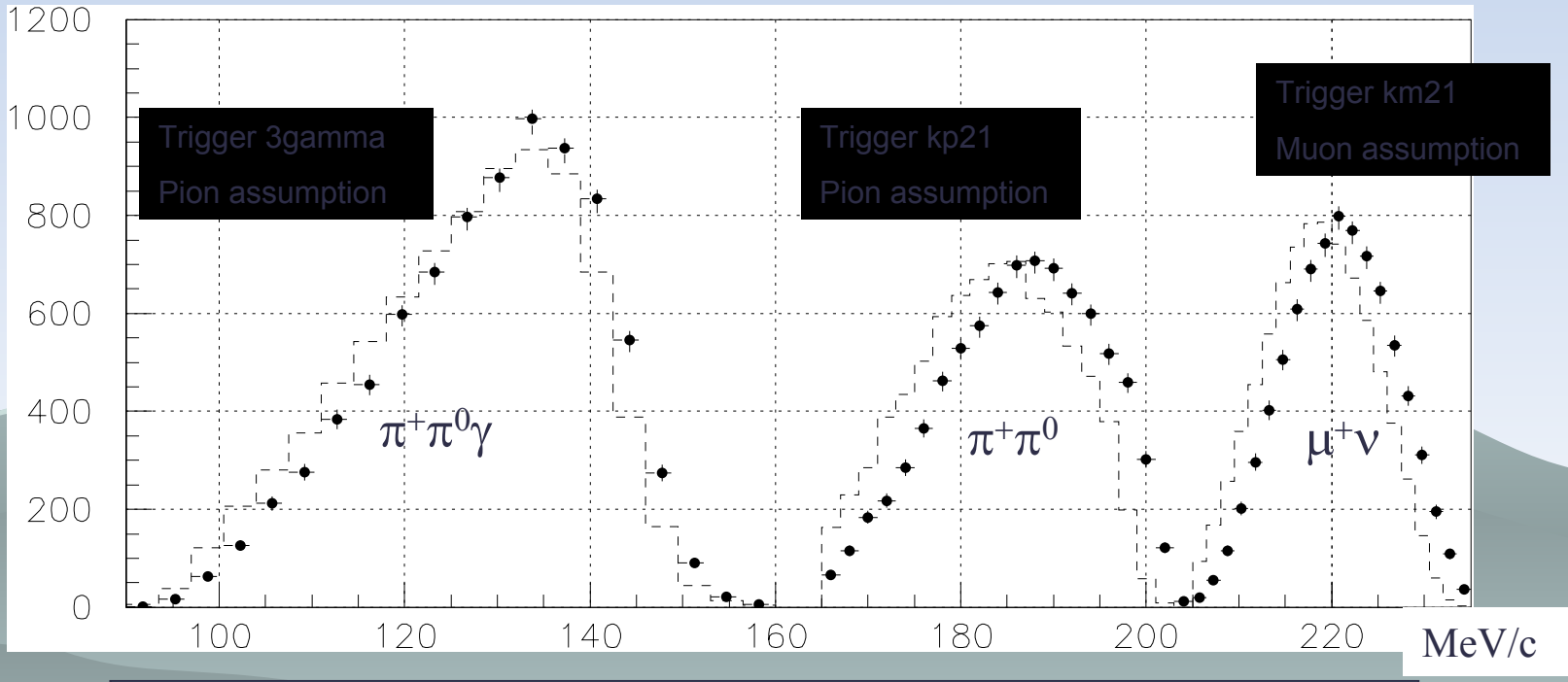
(3) saturation effect

Reconstrucion of momentum and energy



PDC distribution in E787

(momentum measured by Drift Chamber)



Momentum

Distribution of PDC is different between UMC and real data

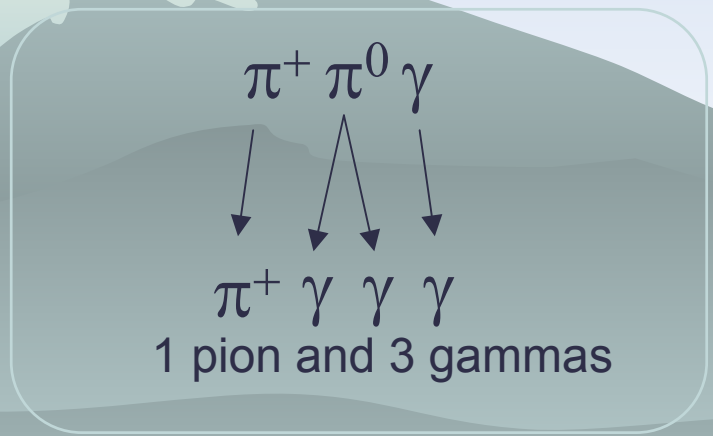
Kinetic fit (most primary cut)

6 constraints

- Momentum conservation (x,y,z 3 constraints)
- Energy conservation
- mass π^+
- mass π^0

13 variables

- Pion Momentum 1
- Energy of pion and gamma 4
- Azimuthal angle 4
- Dip angle 4



Stretch functions

Kinetic fit requires that a stretch function should be a normal Gaussian

$$\text{Stretch function} \equiv \frac{X^i_{meas} - X^i_{fit}}{\sqrt{{\sigma^i_{meas}}^2 - {\sigma^i_{fit}}^2}}$$

X: variable

σ: resolution

There is a shift of measured variable for stretch function to be a normal Gaussian

Shift of measured value

Stretch functions provides us the information on gap of detector position and calibration.

UMC

Pion Momentum	ptot' = ptot + 0.4 + 1.70∗σ MeV/c
Pion energy	etot' = etot + 2.11∗σ MeV
Z positon of gamma	no offset

Real

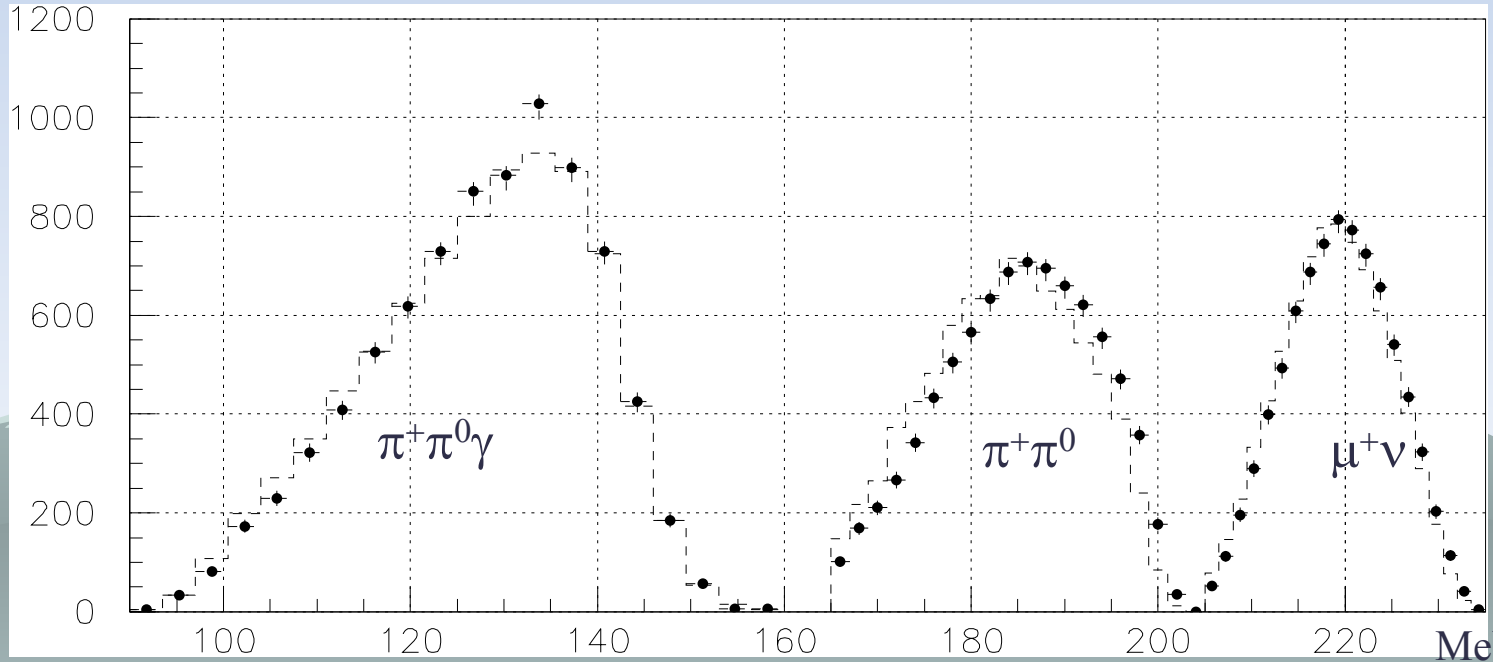
Pion Momentum	ptot' = ptot – 1.4 MeV/c
Pion energy	etot' = etot + 1.8 MeV
Z positon of gamma	ZG = ZG + 0.649 cm

σ :**Normal Gaussian** Smearing parameter is set to the same value used in 1995 analysis

PDC distribution in E787

with offset (momentum measured by Drift Chamber)

• Real
------ UMC

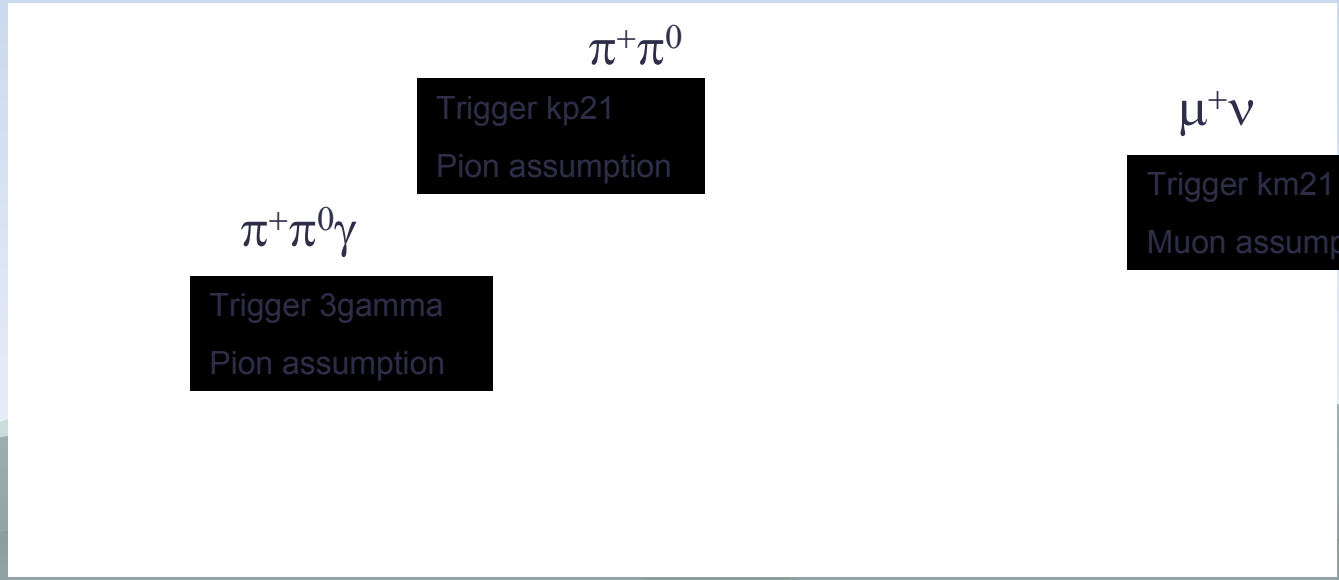


Momentum

PDC explains the discrepancy of momentum between real and UMC

Momentum for kinematic fit

• Real
------ UMC

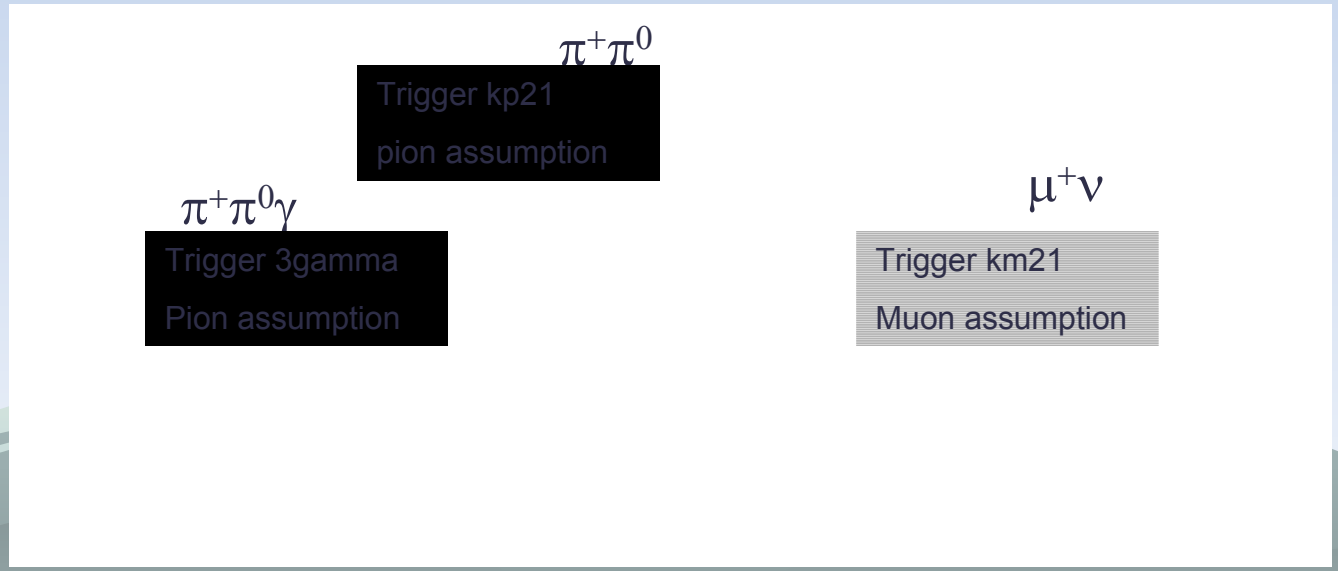


input of momentum for kinetic fit MeV/c

Scale of momentum
Scale of momentum is consistent between UMC and real data

Kinetic energy for kinetic fit

• Real
------ UMC

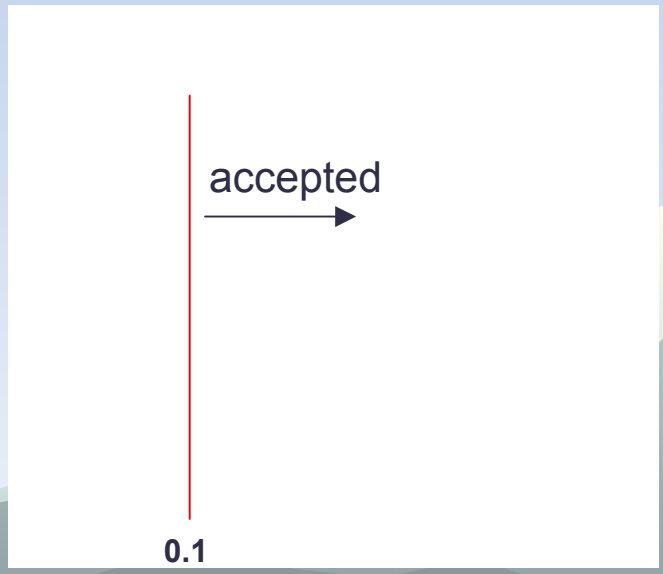


Kinetic energy for input of kinetic fit MeV

Energy for kinematic fit

Scale of momentum and energy scale is different between UMC and real data

Distribution of chisquare probability



IB

Real

Most powerful cut in this analysis

Number of events

’98 data 1/3 sample

Number of events is 8200

(140MeV/c < pion mometum < 180 MeV/c)

Background estimation (real data)

$\pi^+\pi^0$, $\mu^+\pi^0$, $e^+\pi^0\nu$

(Accidental hits)

These backgrounds are tagged by offtime photon

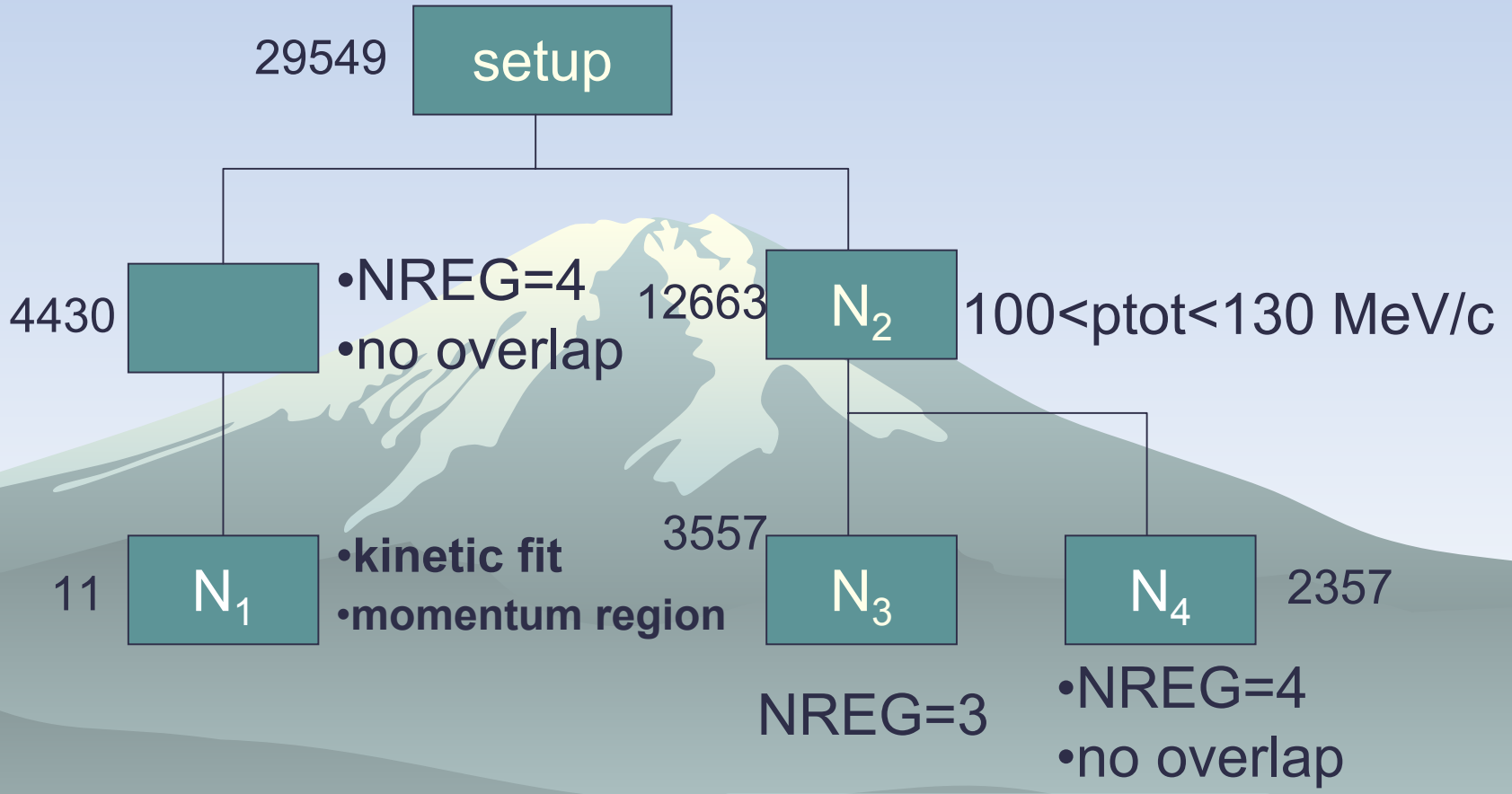
Tagged 755 events

$\pi+/\mu+$ separation
Missing momentum
kinetic fit

10 events remain

$$\frac{N_{bkg}}{\pi^+\pi^0\gamma} = 0.16\%$$

$\pi^+\pi^0\pi^0$ bifurcation



$$N_{bkg} = \frac{N1}{\frac{N4}{N2}} \times \frac{1}{\frac{N2}{N3}} = \frac{N1 \times N3}{N4} = 7.3 events$$

$$\frac{N_{bkg}}{\pi^+\pi^0\gamma} = 0.11\ \%$$

Summary of background estimation

$\pi^+\pi^0$, $\mu^+\pi^0$, $e^+\pi^0\nu$ 0.16%

(Accidental hits)

$\pi^+\pi^0\pi^0$ 0.11%

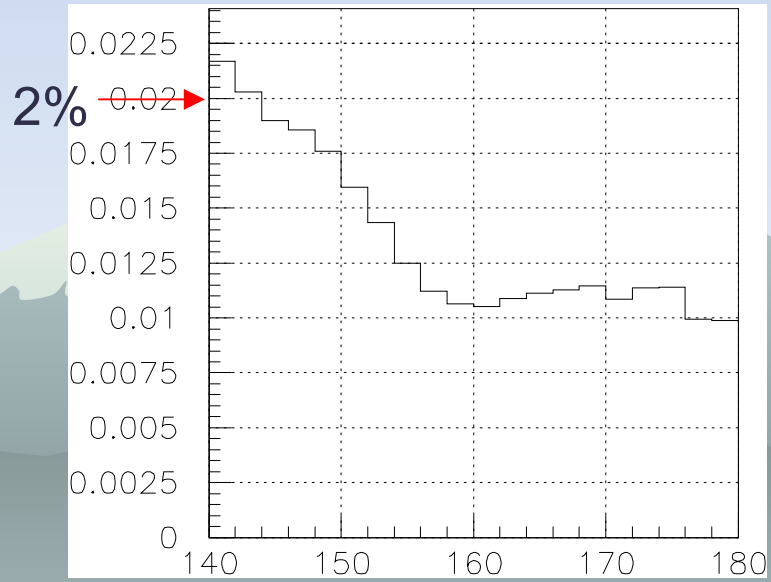
Background estimation

Background level is low.

140 MeV/c < pion momentum< 180 MeV/c

Real data & UMC consistency

Events are rejected if W is larger than 0.4 in order to make more pure IB sample.



DE component is negligible if W < 0.4

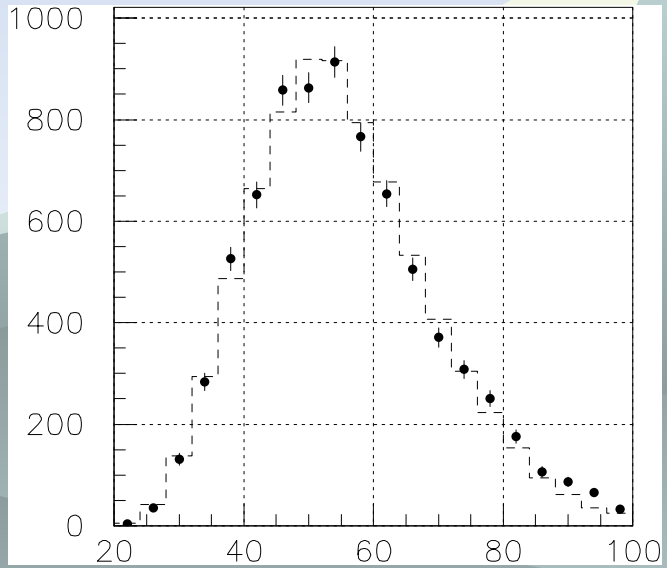
Ratio of DE to IB if BR(DE) is assumed to $4.7*10^{-6}$

Real data & UMC consistency

UMC IB data reproduces the real data?

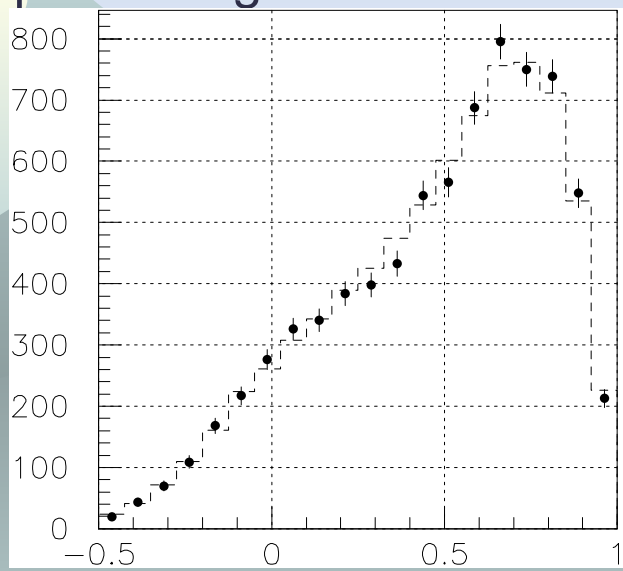
Events are rejected if W is larger than 0.4 in order to make more pure IB sample.

Gamma energy



MeV

Opening angle between pion and gamma



cos

- Real
------- UMC

Real data & UMC consistency

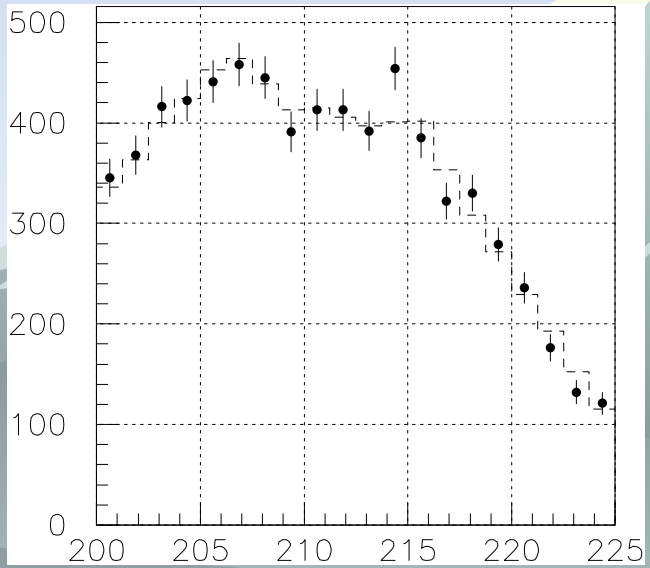
UMC IB data reproduces the real data?

Events are rejected if W is larger than 0.4 in order to make more pure IB sample.

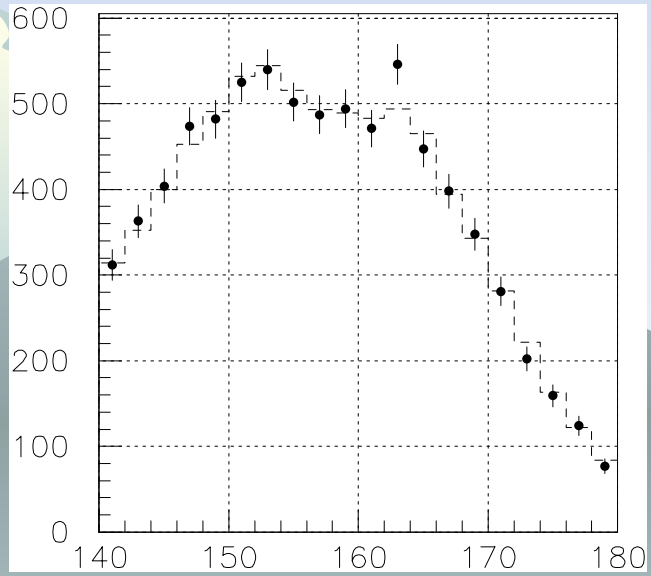
• Real

------- UMC

Pion total energy



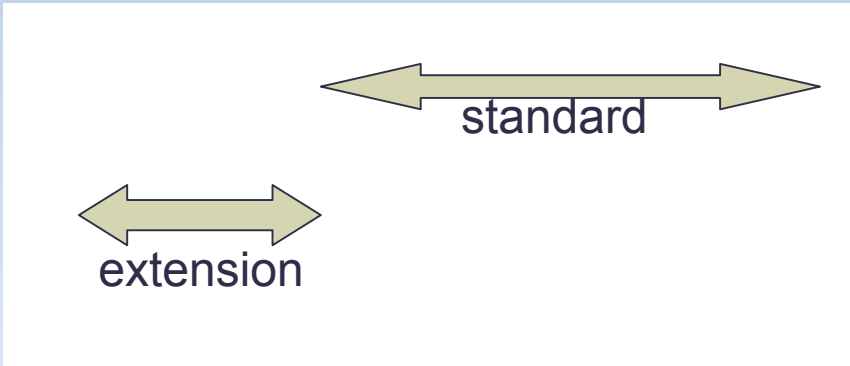
Pion momentum

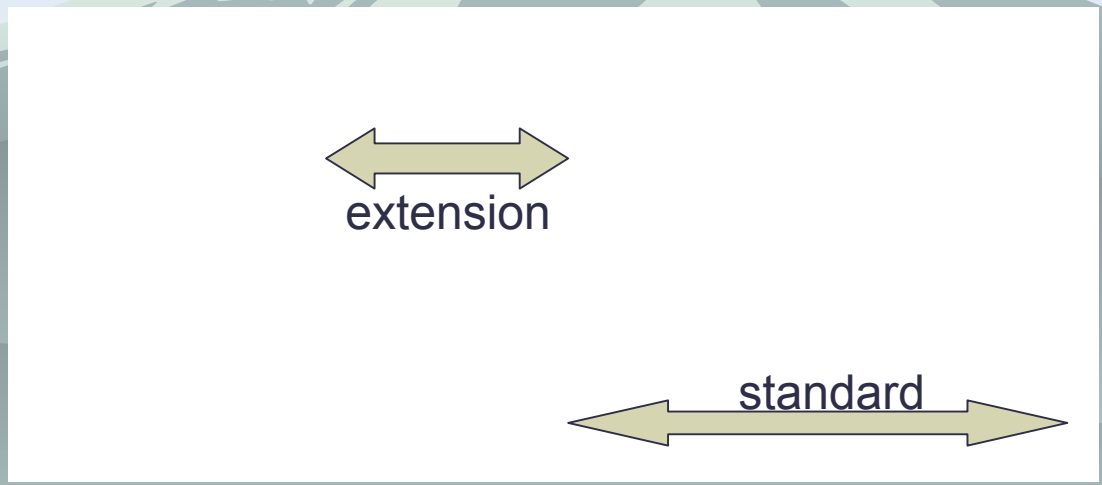


Extension to lower momentum region

IB/DE ratio

Assumuing
BR(DE)=4.7*10^{-6}





- Real
------- UMC(IB)

Assuming that the ratio of IB/DE in 140 MeV/c < P < 180 is the same in lower moentum region

Summary and future prospect

- Correction on target is done
- Consistency between real and UMC is retained.
- Study of lower momentum region